10/521127
PCT/IL 03/00558
Rec'd PCT/PTO 11 JAN 2005

מדינת ישראל
STATE OF ISRAEL

REC'D 13 AUG 2003
WIPO PCT

Ministry of Justice
Patent Office

משרד המשפטים
לשכת הפטנטים

CERTIFIED COPY OF PRIORITY DOCUMENT

BEST AVAILABLE COPY

This is to certify that annexed hereto is a true copy of the documents as originally deposited with the patent application of which particulars are specified on the first page of the annex.

זאת לתעודה כי רצופים בזה העתקים נכונים של המסמכים שהופקדו לכתחילה עם הבקשה לפטנט לפי הפרטים הרשומים בעמוד הראשון של הנספח.

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

10-07-2003
This היום
....
מ. לפרים
ממונה על הבוחנים

רשם הפטנטים
Commissioner of Patents

נתאשר
Certified

לשימוש הלישכה
For Office Use

מספר: Number	**150746**
תאריך: Date	15-07-2002
הוקדם/נדחה Ante/Post-Dated	

חוק הפטנטים, תשכ"ז-1967
Patent Law, 5727 - 1967

בקשה לפטנט
Application for Patent

אני, (שם המבקש, מענו ולגבי גוף מאוגד - מקום התאגדותו)
I, (Name and address of applicant, and in case of body corporate-place of incorporation)

O.D.F. Optronics Ltd.
Toyota Tower, 4th Floor
65 Yigal Alon Street
Tel-Aviv 67443

או. די. אף. אופטרוניקה בע"מ
מגדל טויוטה, קומה 4
רח' יגאל אלון 65
תל-אביב 67443

Inventors: ממציאים:

1. Ehud GAL אהוד גל
2. Gil GRAISMAN גיל גריזמן
3. Gennadiy LITEYGA גנאדי לטיוגה

בעל ההמצאה מכח THE LAW הדין ששמה הוא
Owner, by virtue of THE LAW an invention the title of which is

(בעברית) (Hebrew) עדשה פנורמית מונוליטית

(באנגלית) (English) PANORAMIC IMAGING ASSEMBLY

hereby apply for a patent to be granted to me in respect thereof. מבקש בזאת כי ינתן לי עליה פטנט

*בקשת חלוקה - Application of Division	*בקשת פטנט מוסף - Application for Patent Addition	*דרישה דין קדימה Priority Claim		
*מבקשת פטנט from Application	*לבקשה/לפטנט to Patent/Appl.	מספר/סימן Number/Mark	תאריך Date	מדינת האיגוד Convention Country
№ ____ מס'	№ ____ מס'			
dated ____ מיום	dated ____ מיום			

*יפוי כח: כללי / ~~מיוחד - רצוף בזה~~ / עוד יוגש
P.O.A.: general / ~~individual - attached~~ / to be filed later
filed in case ________ הוגש בענין

המען למסירת מסמכים בישראל
Address for Service in Israel
לוצאטו את לוצאטו
ת.ד. 5352
באר שבע 84152

מספרנו: 14942/02

חתימת המבקש
Signature of Applicant

Luzzatto & Luzzatto
By:
Attorneys for Applicant

היום 15 בחודש יולי שנה 2002
This 15 of יולי of the year 2002

לשימוש הלישכה

טופס זה כשהוא מוטבע בחותם לישכת הפטנטים ומושלם במספר ובתאריך ההגשה, הינו אישור להגשת הבקשה שפרטיה רשומים לעיל.
This form, impressed with the Seal of the Patent Office and indicating the number and date of filing, certifies the filing of the application the particulars of which are set out above.

* מחק את המיותר Delete whatever is inapplicable

1942/02

עדשה פנורמית מונוליטית

PANORAMIC IMAGING ASSEMBLY

14942/02

PANORAMIC IMAGING ASSEMBLY

Field of the Invention

The present invention relates to the field of extremely wide angle imaging. More specifically, it relates to optical structures that enable the coverage of a panoramic or nearly spherical field of view, suitable for video or still imaging.

Background of the Invention

Imaging of a large field of view has many applications in the fields of defense, security, monitoring, entertainment, industry, medical imaging and many other fields. Imaging of a panoramic or nearly spherical field of view, using a single image capturing device, is especially applicable for a variety of needs due to their relative simplicity, low-cost and miniaturization possibilities.

Prior art techniques of panoramic imaging make use of several image capturing devices, each one aimed at a different sector limited in width, combined in a manner that all of them together, when properly aligned, cover a full 360 degrees field of view. Another prior art method for panoramic imaging relies on a single image capturing device, rotated around a vertical axis. In this method the image capturing device covers a limited sector at any single moment, but while completing a full rotation, it creates a sequence of images which are combined together to a panoramic image.

The main disadvantage of the prior art methods is their relative complexity. Some prior art methods necessitate moving/rotating mechanisms, require frequent alignment and very often turn out to be maintenance-intensive.

A different prior art approach makes use of axis-symmetric reflective surfaces, used to reflect a panoramic field of view towards a single image-capture device. In this approach a circular image is formed on the focal plane array of the image capturing device. The shape of the image derives from the reflection of the surrounding field of view by the reflective lens, and often includes aberrations. The image shape and additional aberrations are corrected by image processing techniques. Such prior art design is described in US 6,028,719, in which a method for capturing a nearly spherical field of view is described using a single axis-symmetric reflective mirror with a hole in its center. The main disadvantages of such methods include the relatively complex fabrication of the optical components to achieve high optical performance, its fabrication costs and its sensitivity to environmental conditions. Furthermore, such methods provide relatively poor image quality.

The present invention offers a simpler, cheaper and more robust solution for imaging a panoramic or nearly spherical filed of view using an aspheric optical block and a single image capturing device. Attempts to obtain results similar to those achieved by the

present invention have been made, e.g., in US 6,341,044, which makes use of an optical block and a single image capturing device similar to those of the present invention, to provide panoramic imaging. However, the design used in US 6,341,044 includes a spherical optical block having one refractive surface and one reflective surface. The spherical shape of the optical block and the existence of a single refractive surface incorporated within the optical block itself introduce aberrations that must be corrected by several sets of additional optical lenses along the optical path, as described extensively in the said patent.

As will be described in detail below, the present invention enables the coverage of a panoramic field of view by utilizing a non-spherical optical block, having 2 refractive surfaces and one reflective surface. As a result of the non-spherical shape of the optical block and its additional refractive surface, aberrations are reduced to an acceptable level and do not necessitate additional correction lenses along the optical path of the system, thus simplifying the optical design and structure and reducing production costs.

SUMMARY OF THE INVENTION

According to a first preferred embodiment of the present invention there is provided an imaging assembly capable of imaging a full 360 degrees panoramic field of view. The panoramic imaging assembly comprises an aspheric optical block, the optical design of which dictates the exact shape, curves and the vertical field of view that it covers. The

aspheric optical block comprises a vertical axis of symmetry, a transparent upper concave surface, completely coated with reflective material from its exterior, a transparent perimeter surface and a transparent lower convex surface. Any light ray originating within the field of view, which is covered by the aspheric optical block, will be refracted by the transparent perimeter surface of the aspheric optical block. The ray will then travel within the aspheric optical block and be reflected by the reflective material that coats the exterior of the transparent upper surface. The ray will be reflected towards the transparent lower convex surface, where it will be refracted again and exit the aspheric optical block. Preferably, the panoramic imaging assembly will further comprise an image capturing device located coaxially with the aspheric optical block, directed towards the transparent lower convex surface, the purpose of which is to capture the image that is reflected from the aspheric optical block.

Preferably, but non limitatively, the image capturing device is equipped with its own focusing lens, set to focus on the image that is reflected by the aspheric optical block.

Still preferably, the panoramic imaging assembly further comprises a connector having a first edge and a second edge. The area between the two edges is optically transparent to enable light rays penetrating from the first edge, to arrive and exit through the second edge without distortion.

The shape of the said connector is preferably cylindrical.

According to a preferred embodiment of the invention, the first edge of the connector is designed to attach to the bottom of the aspheric optical block. According to another preferred embodiment of the invention, the second edge of the connector is designed to be mounted on and attached to the said image capturing device, thus fastening and fixating the distance and relation between the aspheric optical block and the image capturing device.

According to yet another preferred embodiment of the invention, the distance between the two edges of the connector is designed to allow optimal focus on the image that is reflected from the aspheric optical block by the image capturing device. The said distance is determined by the optical design and takes into account the characteristics of the aspheric optical block and of the image capturing device.

The said connector may be fabricated together with the aspheric optical block, of the same material, to form a single monolithic optical structure designed for mounting on the image capturing device.

According to another preferred embodiment of the present invention there is provided an imaging assembly capable of imaging simultaneously a first scene of full 360 degrees

panoramic field of view together with a second scene which is located at least partially above the first scene, thus enabling coverage of a nearly spherical field of view. The meaning of the term "above", as used herein and as applied to a "scene", is apparent to persons skilled in the art, and will be further understood by the description of preferred embodiments of the invention provided hereinafter.

The nearly spherical view imaging assembly comprises an aspheric optical block, the optical design of which dictates the exact shape and curves. The optical design also determines the vertical field of view of the first scene that is covered by the aspheric optical block. The aspheric optical block comprises a vertical axis of symmetry, a transparent upper concave surface partly coated with reflective material from its exterior. A transparent area is maintained in the reflective material, around the vertical axis of symmetry. The aspheric optical block further comprises a transparent perimeter surface and a transparent lower convex surface. Any light ray originating within said first scene will be refracted by the transparent perimeter surface of the aspheric optical block. The ray will then travel within the aspheric optical block and be reflected by the reflective material that coats the exterior of the transparent upper surface. The ray will be reflected towards the transparent lower convex surface, where it will be refracted again and exit the aspheric optical block. Any light ray originating at the second scene will be refracted by the transparent area, travel through the aspheric optical block and be refracted by the transparent lower convex surface and exit the aspheric optical block. Light rays

originating at the said first scene and at the said second scene will together provide coverage of a nearly spherical field of view.

The transparent area may be fabricated as a refractive surface as part of the aspheric optical block. For instance, it may be fabricated as a hole formed around said vertical axis of symmetry, extending form the transparent upper concave surface of the aspheric optical block to the transparent lower convex surface of the aspheric optical block.

The nearly spherical view imaging assembly may further comprise an optical structure located coaxially with the said axis of symmetry of the aspheric optical block and above the said transparent area. The said optical structure is designed to refract light rays originating at the said second scene towards the said transparent area.

The optical structure may comprise a plurality of optical elements. Preferably (but not limitatively), the nearly spherical view imaging assembly will further comprise an image capturing device located coaxially with the aspheric optical block, directed towards the transparent lower convex surface.

Still preferably, the image capturing device is equipped with its own focusing lens, set to focus on the image that arrives from the direction of the aspheric optical block.

The nearly spherical view imaging assembly will preferably further comprises a connector having a first edge and a second edge. The area between the two edges is optically transparent to enable light rays penetrating from the first edge, to arrive and exit through the second edge without distortion.

The shape of the said connector is preferably cylindrical.

According to a preferred embodiment of the invention, the first edge of the connector is designed to be attached to the bottom of the aspheric optical block. According to another preferred embodiment of the invention, the second edge of the connector is designed to be mounted on and attached to the image capturing device, thus fastening and fixating the distance and relation between the aspheric optical block and the image capturing device.

In a preferred embodiment of the invention, the distance between the two edges of the connector is designed to allow optimal focus on the image that arrives from the aspheric optical block by the image capturing device. Said distance is determined by the optical design and takes into account the characteristics of the aspheric optical block and of the image capturing device.

The connector may be fabricated together with the aspheric optical block, and can be made of the same material, to form a single monolithic optical structure designed for mounting on the image capturing device.

Brief Description of the Drawings

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, purely by way of example, to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of preferred embodiments of the present invention only. No attempt is made to show in the drawings structural details of the invention in greater detail than is necessary for understanding of the invention. Details not shown in the figures are readily understood by the skilled person who will easily appreciate how the several forms of the invention may be carried out.

In the drawings:

Fig. 1 is a schematic description of an aspheric optical block, which enables the coverage of a panoramic field of view, and a scheme of optical paths of light rays originating from the panoramic field of view;

Fig. 2 is a schematic description of an imaging assembly, which utilizes the aspheric optical block to capture an image of a 360 degrees panoramic field of view;

Fig. 3 is a schematic description of the image shape as acquired by the image capturing device;

Fig. 4 is a schematic description of an aspheric optical block with additional features that enable the coverage of a 360 degrees panoramic field of view and an additional upper sector, and a scheme of optical paths of light rays that originate at the different sectors;

Fig. 5 is a schematic description of an aspheric optical block with additional optical elements that enable coverage of a nearly spherical field of view, and a scheme of optical paths of light rays that originate at the different sectors; and

Fig. 6 is a schematic description of an imaging assembly, which utilizes the aspheric optical block and the additional optical elements to capture an image of a nearly spherical field of view.

Detailed Description of the Invention

A first embodiment of the present invention provides a panoramic imaging assembly based on an aspheric optical block. The aspheric optical block is designed to collect light rays from a surrounding 360 degrees field of view and to reflect them towards an image capturing device located coaxially with it. The aspheric optical block is designed to have a transparent upper concave surface completely coated with reflective material from its exterior, a perimeter aspheric transparent surface and a lower convex transparent surface. Those skilled in the art will appreciate that the exact structure of the aspheric optical

block and the exact formulas describing its curves are subject to precise optical design, well within the scope of the routineer. Proper optical design will preserve maximum quality of the image that is refracted and reflected by the aspheric optical block. It is further noted that the coverage of the vertical field of view is also subject to the optical design and can be controlled by the optical design. The optical design also dictates the required distance between the aspheric optical block and the image capturing device to ensure optimal focus by the image capturing device on the image that is reflected from the aspheric optical block.

Fig. 1 is a schematic description of the aspheric optical block designed for coverage of a 360 degrees panoramic surroundings. The aspheric optical block (1) is fabricated as a single solid optical element comprising a transparent perimeter surface (2), a transparent upper surface (3) and a lower transparent surface (4). The upper surface (3) is coated with reflective material (5) from the exterior, designed to reflect light rays that arrive from the interior of the optical block (1). A first light ray (6) represents a light ray originating at the upper limit of the field of view that is covered by the optical block (1). A second light ray (7) represents a light ray originating at the lower limit of the field of view that is covered by the optical block (1). Reference will now be made to the optical path of light rays which are within the field of view that is covered by the optical block (1). The first light ray (6) hits the perimeter refractive surface at a first point (8), and penetrates the optical block (1). It then travels through the optical block (1) and hits the upper surface

(3) at a second point (9), where it is reflected downwards towards the lower surface (4). The reflection is achieved due to the existence of the reflective material (5) on the exterior of the upper surface (3). After hitting the upper surface (3) at the second point (9), the first light ray (6) travels through the optical block (1) and hits the lower refractive surface (4) at a third point (10). When hitting the lower surface (4), the first light ray (6) is then refracted and exists the optical block. Similar paths can be described in reference to the second light ray (7) and any other light ray that is within the field of view that is covered by the optical block (1). It is stressed that each light ray originating from a different angle will hit different points of the aspheric optical block, and will naturally have different optical paths.

Fig. 2 illustrates an entire imaging assembly, which utilizes the aspheric optical block described in Fig. 1, to enable the capture of a 360 degrees panoramic image. The imaging assembly comprises the optical block (1), a connector (11) and an imaging device (12). The connector (11) is designed to fasten the optical block (1) and the imaging device (12) in their place, and especially to keep a fixed distance and relation between the optical block (1) and the imaging assembly (12). Several designs of the connector (11) are possible. The connector (11) can be either a separate element, or it can be fabricated together with the optical block (1) to form a single monolithic optical structure. The connector is designed to have a first edge (13) and a second edge (14). The first edge (13) of the connector (11) is designed to connect directly to the optical block (1). The optical

block (1) is preferably fabricated together with lower attachment area (15) designed for easy attachment to the first edge (13) of the connector. The second edge (14) of the connector (11) is designed to connect to the image capturing device (12). It is stressed that the area between the first edge (13) and the second edge (14) is optically transparent and allows the image that is reflected from the optical block (1) to travel through the connector (11) and be captured by the image capturing device (12) without distortion. The image capturing device (12) is preferably equipped with its own focusing lens (16), which is set to focus the image that is captured by the image capturing device (12). Those skilled in the art would appreciate that the focusing lens is chosen in accordance with the distance between the image capturing device (12) and the optical block (1), and according to specifications of the optical design. As previously noted, the distance between the image capturing device (12) and the optical block (1) is determined by the optical design to ensure both optimal focus of the image and preferably that the entire image that is reflected by the optical block (1) and no more than the image, is capture by the image capturing device (12).

Fig. 3 is a schematic description of the shape of the image that is acquired by the image capturing device. As described with reference to Fig. 2, the image capturing device captures an image, which is the reflection of the panoramic scene. In Fig. 3, an image (17) is acquired by the image capturing device. The image (17) contains a first area (18), which is the reflection of the panoramic view and a second area (19) which is the

reflection of the image capturing device itself. Every light ray, which originates at the panoramic surrounding at an elevation angle which is covered by the optical block, will appear at the first area (18) in the image (17). It is stressed that the image shape as indicated, describes an image as it is acquired by the image capturing device in a preferable case when the lens of the image capturing device is set to cover all and no more than the reflection, and the reflection appears at the center of the image. The circular shape of the image, although suitable for some needs, may be considered unsuitable for standard viewing. Therefore the image is usually corrected by image processing software, designed specifically according to the parameters of the optical block. Such operation of the software corrects the image shape and transforms it to another shape, preferably rectangular, more suitable for viewing. It is stressed that by using the imaging assembly described by figure 2, the central sector (19) of the image (17) will comprise of the reflection of the image capturing device. Having this area of the image being actually "wasted", it is manipulated by advanced optical designs to comprise of an image of a second scene, at least partially different from the panoramic scene that appears in the outer sector (18) of the image. Those advanced optical designs are described by referring to the second embodiment of this invention in figures 4-6.

Another preferred embodiment of the present invention provides an imaging assembly capable of capturing a first scene of a 360 degrees panoramic surroundings, and a second scene, located at least partially above the first scene. The image capture is achieved using

a unique aspheric optical structure and a single image capturing device. The aspheric optical structure has several possible designed as will be described by the following figures. Those skilled in the art will appreciate that the exact structure of the aspheric optical structure and the exact formulas describing its curves or optical qualities of its components are subject to precise optical design. Proper optical design will preserve maximum quality of the image that is acquired by the image capturing device. It is further noted that coverage of the vertical field of view of the first scene is also subject to the optical design and can be controlled by the optical design. Optical design also dictates the required distance between the aspheric optical block and the image capturing device to ensure optimal focus by the image capturing device on the image that is arrives from the direction of the aspheric optical structure.

Fig. 4 is a schematic description of a possible design of the aspheric optical structure designed for coverage of a first scene comprising a 360 degrees panoramic surroundings and a second scene which is at least partially above the first scene. The aspheric optical structure comprises a single optical element which is an aspheric optical block (20). The aspheric optical block (20) comprises a transparent perimeter surface (21), a transparent upper surface (22) and a lower transparent surface (23). The upper surface (22) is partially coated with reflective material (24) from the exterior, designed to reflect light rays that arrive from the interior of the optical block (20). It is stressed that the upper surface (22) is not coated entirely and a transparent area (25) is maintained in the upper

surface (22) extending through the optical block (20), allowing light rays from a second scene to penetrate the optical block (20) through said transparent area (25). A first light ray (26) represents a light ray originating at the upper limit of the first scene. A second light ray (42) represents a light ray originating at the lower limit of the first scene and a third light ray (27) represents a light ray originating at an extreme edge of the second scene. Reference will now be made to the optical path of light rays which are within the field of view that is covered by the optical block (20). The first light ray (26) hits the perimeter refractive surface at a first point (28), and penetrates the optical block (20). It then travels through the optical block (20) and hits the upper surface (22) at a second point (29), where it is reflected downwards towards the lower surface (23). The reflection is achieved due to the existence of the reflective material (24) on the desired area on the exterior of the transparent upper surface (22). After hitting the upper surface (22) at the second point (29), the first light ray (26) travels through the optical block (20) and hits the lower refractive surface (23) at a third point (30). When hitting the lower surface (23), the first light ray (26) is then refracted and exists the optical block. Similar paths can be described in reference to the second light ray (42) and any other light ray that is within the first scene. The third light ray (27) hits the transparent area (25) in the upper surface (22) at a fourth point (31), where it is refracted and enters the optical block (20). The ray then travels through the optical block (20) until reaching the lower surface (23) where it hits at a fifth point (32). The ray is then refracted and exists the optical block (20). It is

stressed that each light ray originating from a different angle will hit different points of the optical block, and will naturally have different optical paths.

Fig. 5 illustrates another possible design of the aspheric optical structure that enables coverage of a nearly spherical field of view. In this figure an aspheric optical block (20) is used, having the same qualities as indicated with reference to Fig. 4. In this figure an additional optical structure (33) is placed above the transparent area (25) and coaxially with the vertical axis of symmetry of the aspheric optical block (20). The lens is preferably fabricated in a size that enables exact placement and fastening to the aspheric optical block. A main advantage of using an additional optical structure (33) over a simple transparent area (25) as shown in Fig. 4, is that the use of an additional optical structure, when properly designed, enables control over the size of second scene that is covered. A light ray (34) represents a light ray that originates at the extreme edge of the second scene. Reference will now be made to the optical path of the light ray (34). The ray (34) hits the additional optical structure (33) at an entrance point (35) where it is refracted and penetrates the additional optical element (33). The ray (34) then travels through the additional optical element (33) and may be refracted again several times, should the additional optical structure be comprised of several separate optical elements. The ray exits the additional optical structure (33) at an exit point (36) where it is refracted again and travels towards the transparent area (25). The ray (34) then hits the transparent area (25) at a first point (37), where it is refracted and enters into the optical block (20).

The ray then travels through the optical block (20) until it hits the lower surface (23) at a second point (38), where it is refracted again and exits the optical block. As previously indicated, the additional optical structure (33) is designed to control the size of the second scene that will be covered. The additional optical structure (33) may be comprised of several separate optical elements to compensate any aberrations that may be generated along the optical path of light rays that originate at the second scene.

Fig. 6 describes an entire imaging assembly, which utilizes the aspheric optical structure described in Figs. 4 and 5, to enable capture of both a first scene of a 360 degrees panoramic surroundings and a second scene, which is at least partially located above the first scene. The imaging assembly comprises the optical block (20), a connector (11) and an imaging device (12). It is stressed that the aspheric optical structure (20) illustrated in this image comprises several additional optical elements (39) and (40). However, this is done purely by way of illustrative description and is not obligatory. As previously indicated, the exact number and qualities of the additional optical elements is subject to optical design. The connector (11) is designed to fasten the optical block (20) and the imaging device (12) in their place, and especially to keep a fixed distance and relation between the aspheric optical structure (20) and the imaging assembly (12). Several designs of the connector (11) are possible. The connector (11) can be either a separate element, or it can be fabricated together with the aspheric optical block (20) to form a single monolithic optical structure. The connector is designed to have a first edge (13)

and a second edge (14). The first edge (13) of the connector (11) is designed to connect directly to the optical block (20). The optical block (20) is preferably fabricated together with lower attachment area (41) designed for easy attachment to the first edge (13) of the connector (11). The second edge (14) of the connector (11) is designed to connect to the image capturing device (12). It is stressed that the area between the first edge (13) and the second edge (14) is optically transparent and allows the image that arrives from the direction of the aspheric optical block (20) to travel through the connector (11) and be captured by the image capturing device (12) without distortion. The image capturing device (12) is preferably equipped with its own focusing lens (16), which is set to focus the image that is captured by the image capturing device (12). Those skilled in the art would appreciate that the focusing lens is chosen in accordance with the distance between the image capturing device (12) and the aspheric optical structure (20), and according to specifications of the optical design. As previously noted, the distance between the image capturing device (12) and the aspheric optical structure (20) is determined by the optical design to ensure both optimal focus of the image and preferably that the entire image that arrives from the direction of the aspheric optical structure (20) and no more than the image, is capture by the image capturing device (12).

It is stressed that the transparent area (25) described in figures 4-6 may be fabricated in several methods. A first method is forming only a partial reflective coating over the transparent upper surface, leaving an area around the vertical axis of symmetry of the

aspheric optical block uncoated, thus allowing light rays to penetrate the aspheric optical block. Another way of fabrication of the transparent area (25) is to produce a refractive surface on top of the transparent upper surface by imposing a different curvature on an area around the vertical axis of symmetry of the aspheric optical block. This will cause the transparent area to have different refraction qualities. A third method is by forming a hole along the vertical axis of symmetry of the aspheric optical block, at a certain diameter, to allow light rays to pass freely through the said hole. However, it should be appreciated that each method will necessitate a different design of additional optical elements to be placed along the optical path of light rays originating at the second scene.

All the above description of preferred embodiments has been provided only for the purpose of illustration, and is not intended to limit the invention in any way. As will be appreciated by the skilled person, many variations and modifications are possible, without exceeding the scope of the invention.

Claims

1. A panoramic imaging assembly comprising an aspheric optical block, said aspheric optical block having:

   a) a vertical axis of symmetry;

   b) a transparent upper concave surface, completely coated with reflective material from its exterior;

   c) a transparent perimeter surface; and

   d) a transparent lower convex surface;

   wherein light from a 360 degrees panoramic scene is refracted by the said transparent perimeter surface, is then reflected by said reflective material towards said transparent lower convex surface, is then refracted by said transparent lower convex and exits through said transparent lower convex surface.

2. A panoramic imaging assembly according to claim 1, further comprising an image capturing device, directed toward said transparent lower convex surface of said aspheric optical block, having its optical axis coinciding with said vertical axis of symmetry of said aspheric optical block.

3. A panoramic imaging assembly according to claim 2, wherein said image capturing device comprises a focusing lens.

4. A panoramic imaging assembly according to claim 2, further comprising a connector having a first edge and a second edge, wherein optical transparency exists between said first edge and said second edge, allowing light penetrating from said first edge to reach and exit through said second edge essentially without distortion.

5. A panoramic imaging assembly according to claim 4, wherein said connector is cylindrical in shape.

6. A panoramic imaging assembly according to claim 4, wherein said first edge of said connector is designed to be connected to said aspheric optical block.

7. A panoramic imaging assembly according to claim 4, wherein said second edge of said connector is designed to be mounted on and connected to said image capturing device.

8. A panoramic imaging assembly of claim 4, wherein the distance between said first edge of said connector and said second edge of said connector is designed to allow optimal focus by the said image capturing device on the image reflected by said aspheric optical block.

9. A panoramic imaging assembly according to claim 4, wherein said connector is fabricated together with said aspheric optical block to form a single monolithic optical structure.

10. A nearly spherical view imaging assembly comprising an aspheric optical block, said aspheric optical block having:

a) a vertical axis of symmetry;

b) a transparent upper concave surface, coated with reflective material from its exterior;

c) a transparent area maintained through said reflective material around said vertical axis of symmetry;

d) a transparent perimeter surface; and

e) a transparent lower convex surface;

wherein light from a 360 degrees panoramic scene is refracted by the said transparent perimeter surface, is then reflected by said reflective material towards said transparent lower convex surface, is then refracted by said transparent lower convex surface and exits through said transparent lower convex surface and light from a second scene, located at least partially above said 360 degrees panoramic scene, is refracted by said transparent area, then refracted by said transparent lower convex surface and exits through said transparent lower convex surface.

11. A nearly spherical view imaging assembly according to claim 10, wherein said transparent area of said aspheric optical block is fabricated as a refractive surface as part of the said aspheric optical block.

12. A nearly spherical view imaging assembly according to claim 10, wherein said transparent area of said aspheric optical block is fabricated as a hole around said vertical axis of symmetry extending from said reflective material to said transparent lower convex surface.

13. A nearly spherical view imaging assembly according to claim 10, further comprising an optical structure located coaxially with said vertical axis of symmetry of said aspheric optical block and above said transparent area, said optical structure being designed to refract light from a scene located at least partially above said 360 degrees panoramic scene, toward said transparent area.

14. A nearly spherical view imaging assembly according to claim 13, wherein said optical structure comprises a plurality of optical elements.

15. A nearly spherical view imaging assembly according to claim 10, further comprising an image capturing device, directed towards said transparent lower convex surface of

said aspheric optical block, having its optical axis coinciding with said vertical axis of symmetry of said aspheric optical block.

16. A nearly spherical view imaging assembly according to claim 15, wherein said image capturing device comprises a focusing lens.

17. A nearly spherical view imaging assembly according to claim 10, further comprising a connector having a first edge and a second edge, wherein optical transparency exists between said first edge and said second edge, allowing light penetrating from said first edge to reach and exit through said second edge essentially without distortion.

18. A nearly spherical view imaging assembly according to claim 17, wherein said connector is cylindrical in shape.

19. A nearly spherical view imaging assembly according to claim 17, wherein said first edge of said connector is designed to be connected to said aspheric optical block.

20. A nearly spherical view imaging assembly according to claim 17, wherein said second edge of said connector is designed to be mounted on and connected to said image capturing device.

21. A nearly spherical imaging assembly according to claim 17, wherein the distance between said first edge of said connector and said second edge of said connector allows optimal focus by the said image capturing device on the image that arrives from the direction of said aspheric optical block.

22. A nearly spherical imaging assembly according to claim 17, wherein said connector is fabricated together with said aspheric optical block to form a single monolithic optical structure.

לוצאטו את לוצאטו
LUZZATTO & LUZZATTO
By ע״י

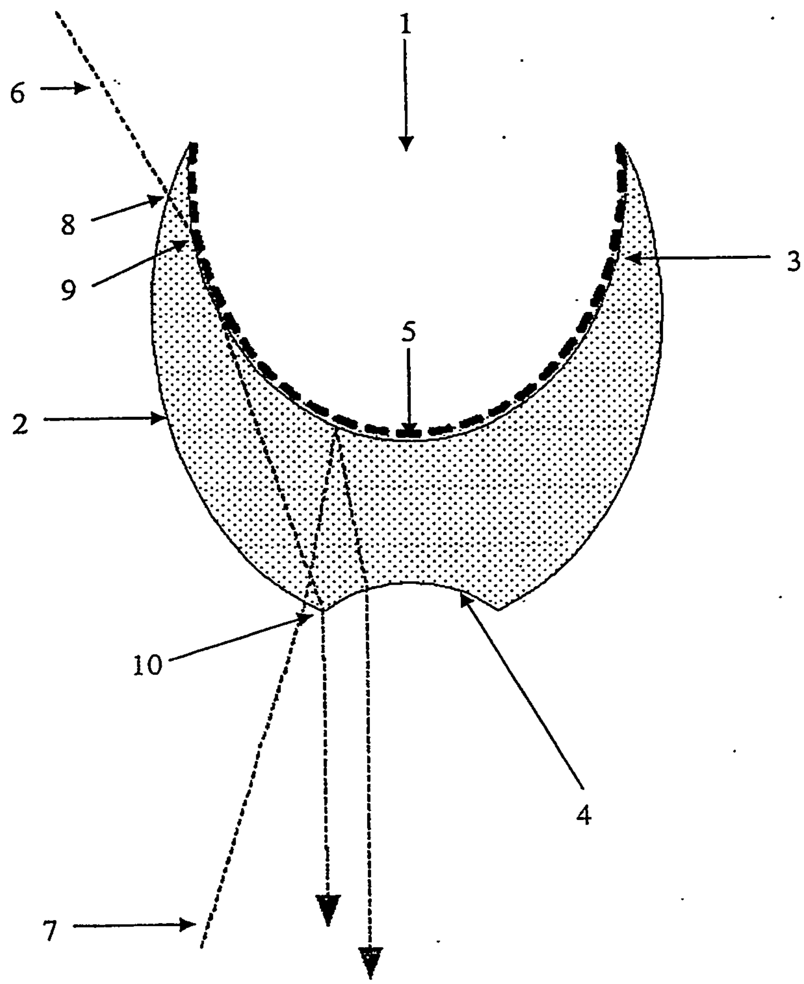

Fig. 1

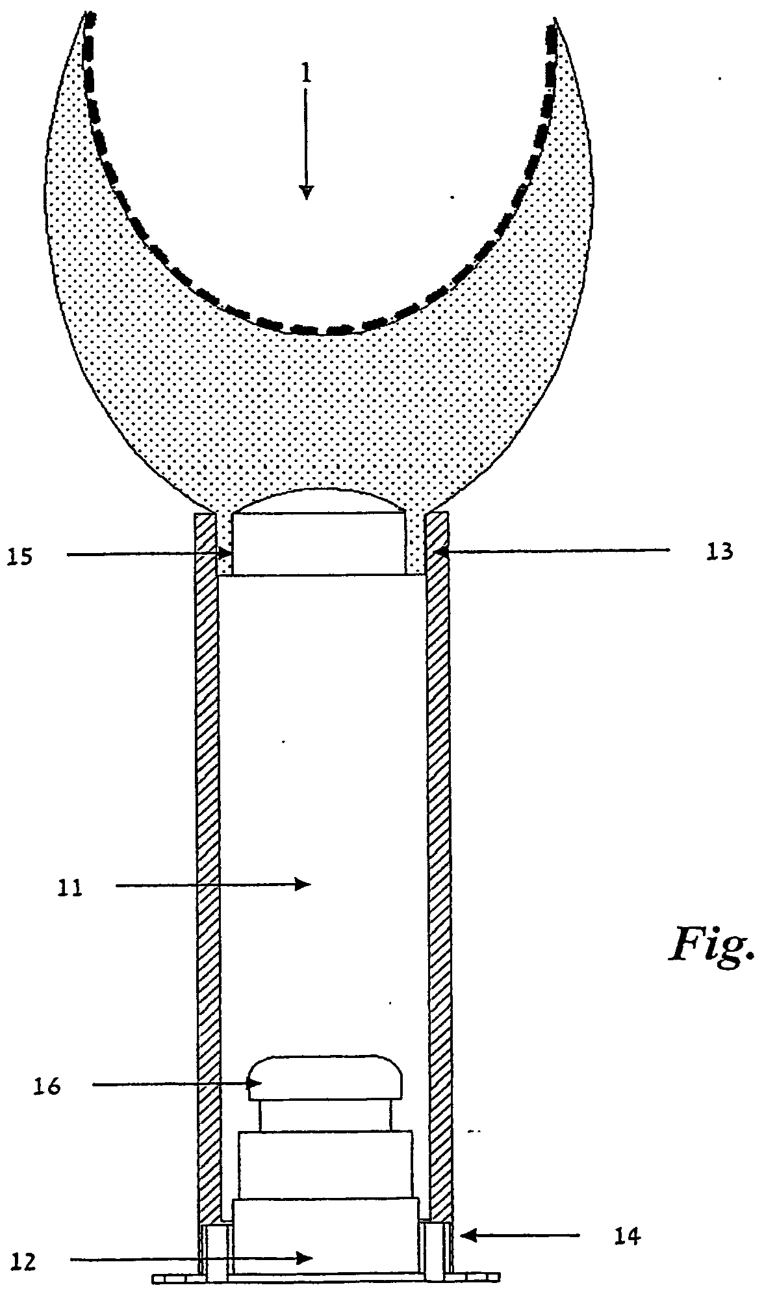

Fig. 2

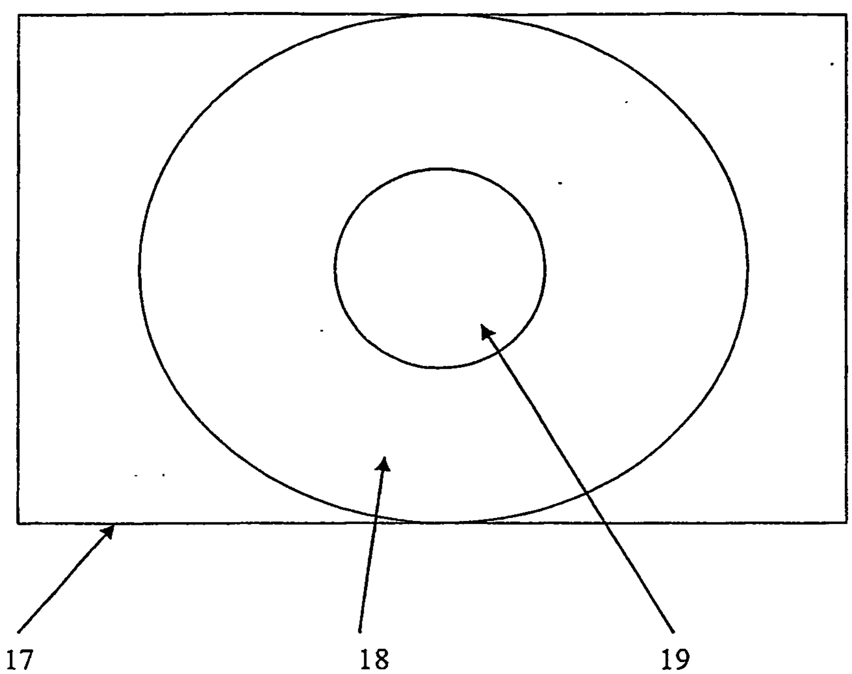

Fig. 3

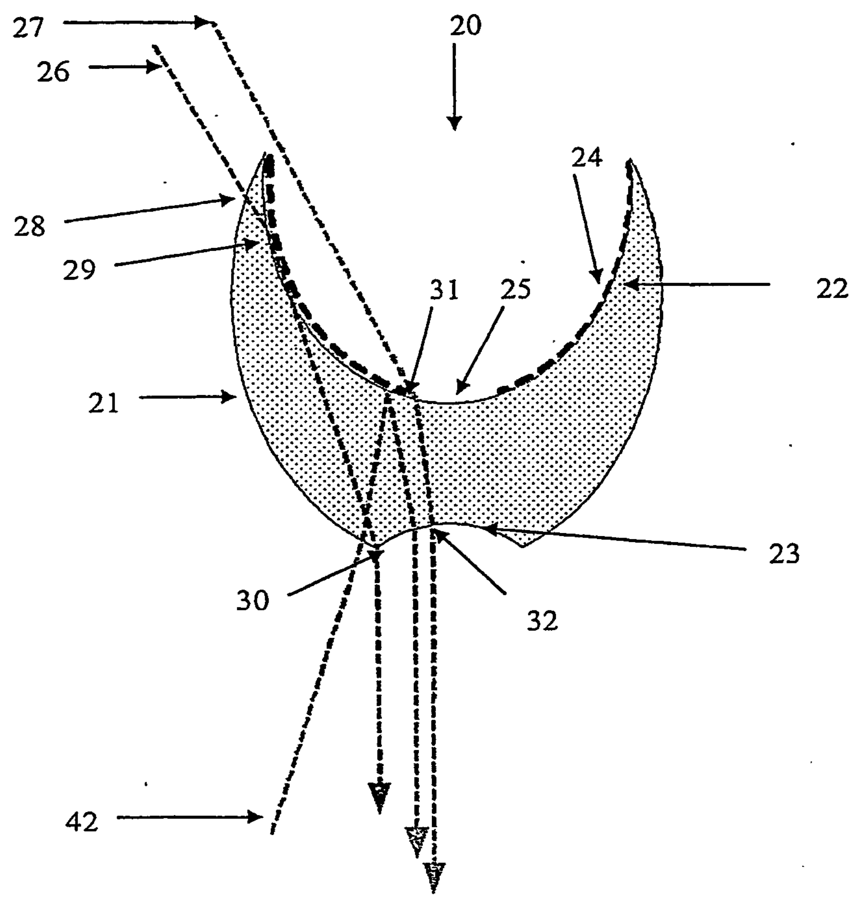

Fig. 4

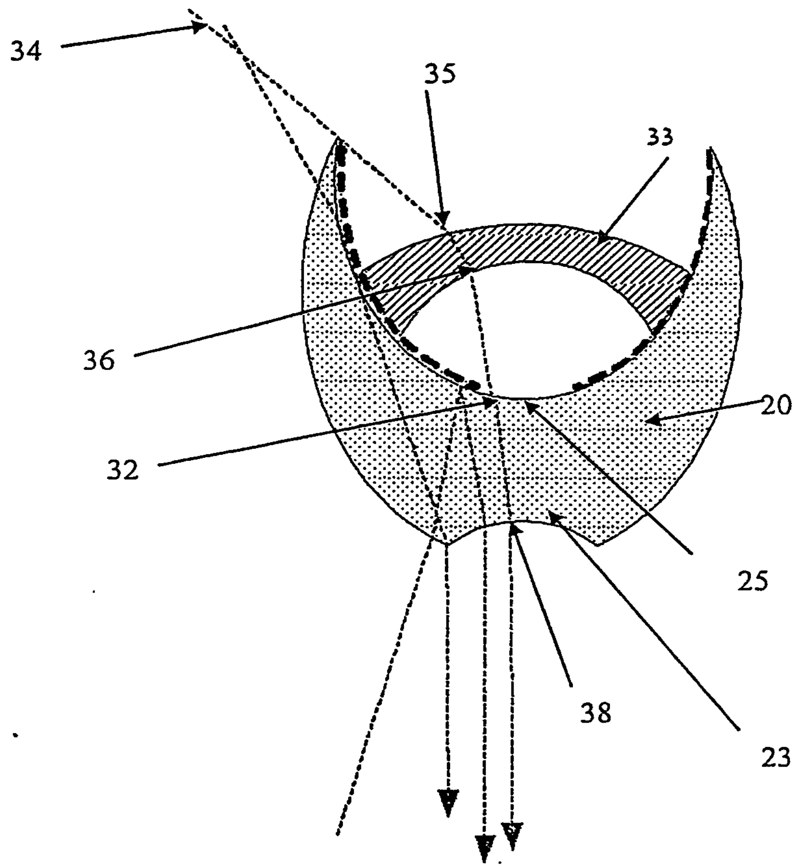

Fig. 5

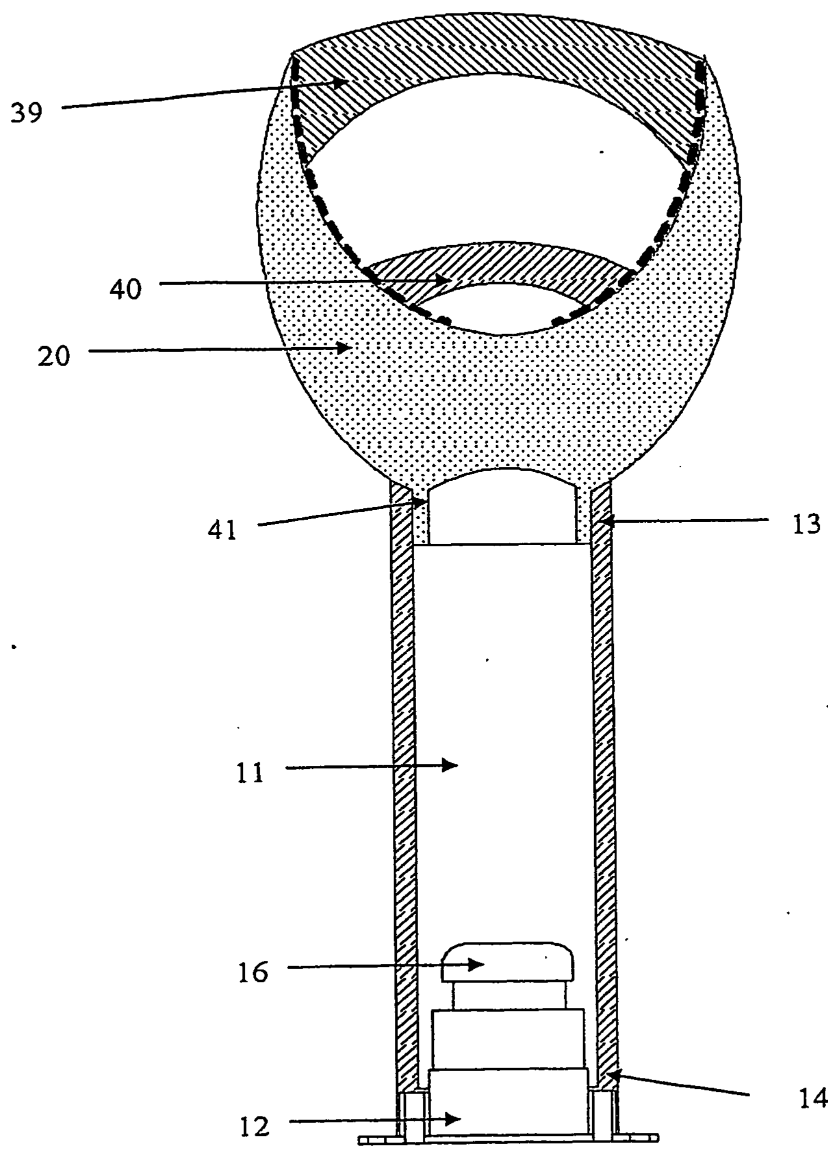

Fig. 6